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APOLLO 14 (MISSION H-3) BASELINE
MISSION PROFILE


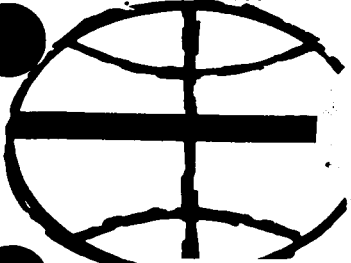
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Lunar Mission Analysis Branch

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS


(NASA-TM-X-69432) APOLLO 14 (MISSION
H-3) BASELINE MISSION PROFILE (NASA)

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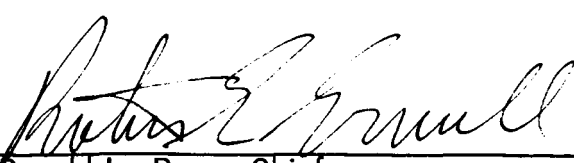
PROJECT APOLLO

APOLLO 14 (MISSION H-3) BASELINE MISSION PROFILE

By Lunar Mission Design Section
Lunar Mission Analysis Branch

December 31, 1969

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

Approved: 

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FOREWORD

Preliminary Apollo 14 (Mission H-3) trajectory data for the July 1970 launch window are presented in this document. A general mission profile is presented, and approximate variations of selected mission parameters are indicated. Note that the information in this document is preliminary and will be updated in the Apollo 14 (Mission H-3) operational trajectory documents. Questions about the information in this document should be directed to Gene Winston Ricks, extension 5476.

The profile developed within the enclosed constraints and guidelines is under Configuration Control and will be published in detail in the subsequent Operational Trajectory (OT). Changes to this profile or to the constraints and guidelines will be considered through January 12, 1970. The OT inputs will be frozen on that date. Changes can be processed through the trajectory change request (TCR) procedure. TCR's can be submitted to either the ASPO mission staff engineer (Stan Blackmer) or the MPAD mission design manager (John Gurley).

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SYMBOLS

CSM	command/service module
DOI	descent orbit insertion (CSM/LM)
DPS	descent propulsion system
EI	entry interface
EPO	earth parking orbit
I_{sp}	specific impulse
LM	lunar module
LOI	lunar orbit insertion maneuver
LOPC-1	lunar orbit plane change for LM rendezvous
LOPC-2	lunar orbit plane change for photographic mission (bootstrap)
LPO	lunar parking orbit
MSFN	Manned Space Flight Network
SM	service module
SPS	service propulsion system
TEI	transearth injection
TLI	translunar injection
ΔV	change in velocity

PRELIMINARY APOLLO 14 (MISSION H-3) TRAJECTORY DATA

By Lunar Mission Design Section

1.0 MISSION GROUND RULES AND GUIDELINES

The primary guidelines used in the generation of these preliminary trajectory data are listed below.

1. Acceptable lighting at lunar landing between elevations of 5° to 20° except for the 14° to 18° region; preferred range of 5° to 14° .
2. The mission will be designed for a Pacific translunar injection (TLI). Two TLI opportunities will be targeted, one each in the second and third revolutions.
3. The hybrid transfer maneuver will be planned for TLI plus 28 hours. After the maneuver, the spacecraft will be on a non-free-return trajectory within the DPS delta velocity (ΔV) capability for an earth return at LOI ignition plus 2 hours.
4. Launch is scheduled from pad 39A with a launch azimuth range of 72° to 96° .
5. Lunar orbit insertion will be performed in two stages. The first burn, LOI, will result in a 60- by 170-n. mi. elliptical orbit. The second burn, DOI, will result in a 60- by 8-n. mi. elliptical orbit. The DOI burn will occur approximately two revolutions after LOI. This places the CSM/LM in the orbit from which the LM will perform PDI.
6. The lunar surface staytime will be approximately 32 hours. The lunar orbit orientation will be restricted to permit an any-orbit lift-off.
7. For bootstrap photography, stay as long in LPO after docking as practical.
8. Site 6R will be targeted for the recycle site.
9. Only one backup launch month will be targeted for each mission.

10. The primary landing site is Littrow at 21.736°N latitude and 28.950°E longitude. Apollo site 6R is the backup site at 2.766°S latitude and 42.683°W longitude.

11. The prime launch date to Littrow is July 5, 1970. Launches to the backup site in July are not scheduled because of the strong desire to land at the prime site. In August, the backup launch month, two launch dates to Littrow are scheduled approximately 24 hours apart, and one launch date is planned to 6R.

12. TLI will be targeted to provide a free-return circumlunar trajectory.

13. The S-IVB will perform an evasive maneuver following transposition and docking. The S-IVB blowdown will be targeted to impact the vehicle near the Apollo 13 landing site (Fra Mauro).

14. Goldstone or Parks 210-foot dish coverage of the lunar landing is required for nominal mission planning. There is no mission constraint requiring 210-foot coverage of the EVA.

15. The mission will be designed so the spacecraft will pass over the landing site in revolution 14.

16. Spacecraft undocking and separation will occur in revolution 12 approximately 28 to 30 minutes prior to passing over the landing site. The soft undocking and separation is performed by the CSM. The separation maneuver is an SM/RCS burn, radially down toward the moon to achieve 1-fps ΔV .

17. The CSM will circularize at the beginning of revolution 13. This allows one pass for landing site tracking which is mandatory for pin-point landing and results in contingency rendezvous similar to Apollo 12. Actually, the CSM orbit will be biased to provide a circular orbit at the nominal CDH time.

18. Powered descent and landing will occur in revolution 14. The descent targeting philosophy from Apollo 12 will be used.

19. A CSM plane change will be made after LM landing between the first EVA and the rest period to place the landing site in the orbital plane at the time of nominal LM lift-off.

20. The nominal LM ascent phase and the rendezvous will be designed to be like those of Apollo 12.

21. Ascent stage jettison will occur approximately 270° (central angle) prior to the deorbit maneuver. The deorbit maneuver will be designed as on Apollo 12 to cause impact to occur in the vicinity of the Littrow landing site. A minimum of 2 hours will be allowed between CSM/LM docking and LM jettison.

22. The lunar orbit will be designed within the SPS capability to return to earth from any orbit and for any situation including cryogenic tank failure.

23. After LM jettison, a plane change will be made to provide photographic coverage of Hadley, located at 24.783°N latitude and 2.450°E longitude. The plane change will occur on revolution 39.

24. The TEI maneuver is planned to occur at the end of revolution 45. The maneuver will be targeted to return as soon as possible to 169.5°W longitude within the available ΔV capability and without exceeding a return inclination of 40° .

25. The nominal earth relative entry range target will be 1250 n. mi.

26. The maximum H-3 mission duration is 10.7 days.

27. Any orbit return to earth is required.

28. The maximum inclination of a nominal return is 40° .

29. The maximum inclination of a contingency return with DPS is 90° .

2.0 NOMINAL MISSION PROFILE AND LAUNCH WINDOW SUMMARY

A brief summary of the nominal Apollo 14 (H-3) mission (72° launch azimuth, first translunar injection opportunity, on July 5) is provided in table I.

The Apollo 14 (Mission H-3) launch window for July 1970 is summarized in figure 1.

3.0 EARTH ORBITAL COAST (EPO) TIMES AND TRANSLUNAR INJECTION (TLI) POSITIONS

The EPO coast time variations for both injection opportunities are shown in table III. The TLI ignition positions for both July launch days are presented in figure 2.

4.0 CIRCUMLUNAR TRAJECTORY SUMMARY

The translunar flight times, free-return perilune altitudes, hybrid transfer maneuver ΔV , and the DPS ΔV required for a safe earth return at perilune plus 2 hours are indicated in table III.

5.0 LUNAR ORBIT INSERTION (LOI), LUNAR LANDING SITES, AND LUNAR PARKING ORBIT SUMMARIES

The approximate LOI ΔV variations for each day are presented in table IV.

The prime and backup^a lunar landing sites for July and August are shown in figure 3. Also included are possible future Apollo landing sites.

The sun elevations at lunar landing, approach paths to the sites and orbital inclinations both at the time of LM descent and at the time of LM ascent, and CSM plane change ΔV 's (for inplane LM rendezvous) are presented in table V (a) and (b). In table VI (a) and (b) are shown sun elevations at the July and August photographic sites, the CSM plane change ΔV 's required for the photographic and tracking orbits, post-plane change orbital inclinations and nodal longitudes, and the approximate time from launch of closest approach to the photographic sites. The lunar orbit timeline is presented in figure 4.

^aThis information is supplied for general information only because it is not planned to go to the backup site in July. This information will not be included in the Operational Trajectory.

6.0 TRANSEARTH SUMMARY

Variations in TEI ΔV , transearth flight time, entry velocity, local time of earth landing, and total mission time are given in table VII (a) and (b). The TEI maneuver was targeted to the planned recovery area, (mid-Pacific line) to return as soon as possible within available SPS ΔV capability and within a return inclination limit of 40° .

7.0 END OF MISSION SUMMARY

Variations in end of mission SPS ΔV reserves are presented in table VIII (a) and (b). Two types of reserves are shown. The first type represents the reserves for a nominal mission without contingencies (such as LM rescue) that result in excess SPS consumption. Reserves shown are for missions designed for completion of the photographic objectives and a return to the planned recovery area as soon as possible within available SPS ΔV capability and within a return inclination limit of 40° . The second type of reserves shown assume a worst case LM rescue, no bootstrap photography, and a slow return to earth. Both types allow for a translunar midcourse correction of 120 fps and for total SPS propellant allowances of 585 pounds (3σ low) for start losses, unbalance meter, I_{sp} and mixture ratio uncertainties.

8.0 NOMINAL EARTH LANDING POSITIONS

The nominal return earth landing positions are indicated in figure 5.

TABLE I.- SEQUENCE OF EVENTS FOR JULY 5, 1970 NOMINAL MISSION WITH

A 72° LAUNCH AZIMUTH, FIRST INJECTION OPPORTUNITY

Event	Time, ^a hr:min:sec, g.e.t.	Data summary
Launch	00:00:00	G.m.t., hr:min:sec, July 5, 1970 13:51:28 E.s.t., hr:min:sec, July 5, 1970 8:51:28 Azimuth, deg 72 Pad 39A
Earth orbit insertion	00:11:19	Latitude, deg N 32.7 Longitude, deg W -54.3 Inclination, deg 32.6
Translunar injection	2:48:10	
Non-free-return transfer maneuver	30:48:10	ΔV , fps 26.1
Lunar orbit insertion (LOI)	77:20	Inclination of LPO, deg 21.7 ΔV , fps 2958
CSM/LM DOI	81:28	ΔV , fps 169.3
LM separation (minifootball)	99:47	ΔV , fps 2.5
PDI	104:00	Ignition longitude, deg 43.9
Landing	104:12	Sun elevation at site, deg 12.1 Latitude, deg:min N 21:44 Longitude, deg:min E 28:57 First EVA, hr:min, g.e.t. 109:07

^aTime refers to g.e.t. of ignition for burns.

TABLE 1.- SEQUENCE OF EVENTS FOR JULY 5, 1970 NOMINAL MISSION WITH

A 72° LAUNCH AZIMUTH, FIRST INJECTION OPPORTUNITY - Concluded

Event	Time, ^a hr:min:sec, g.e.t.	Data summary
Lunar orbit plane change 1	113:26	Plane change, deg ΔV, fps 0.9 85
Second pass	135:31	
Ascent (LM lift-off)	135:32	
Docking	138:49	
CSM separation maneuver	140:49	ΔV, fps 1.5
Lunar orbit plane change 2 (for photography)	152:52	Plane change, deg ΔV, fps 2.22 207
CSM pass over Hadley	157:20	Sun elevation at site, deg 13
Transearth injection	166:03	Plane change, deg ΔV, fps 2.0 2876
Entry interface	241:16	Velocity, fps Flight-path angle, deg Latitude, deg Longitude, deg Time from TEI, hr:min 36 044.7 -6.48 8.97 -177.78 76:17
Landing	241:30	Latitude, deg Longitude, deg Local time, hr:min, a.m. Time of sunrise, hr:min, a.m. 16.9 -169.5 6:31 5:34

^aTime refers to g.e.t. of ignition for burns.

TABLE II.- EARTH PARKING ORBIT COAST TIME VARIATIONS

(a) July

Injection opportunity	Launch azimuth, deg	Variation for launch on July 5, hr:min	Variation for launch on July 10, hr:min
1	72	2:31	2:45
	96	2:22	2:37
2	72	4:00	4:13
	96	3:50	4:05

(b) August

Injection opportunity	Launch azimuth, deg	Variation for launch on August 3, hr:min	Variation for launch on August 9, hr:min
1	72	2:36	2:48
	96	2:27	2:43
2	72	4:05	4:17
	96	3:56	4:11

TABLE III.- CIRCUMLUNAR TRAJECTORY SUMMARY

Parameter	Launch date			
	July 5, 1970	July 10, ^a 1970	August 3, 1970	August 9, 1970
Translunar flight time, hr	75.5	86	84.7	78
Free-return perilune altitude, n. mi.	60	1800	1000	900
Hybrid transfer maneuver ΔV , fps	26	57	36	41
DPS ΔV required for earth return at perilune +2 to 10 hr, fps	905	1855	1264	1531

^aThis information is supplied for general information only because it is not planned to go to the backup site in July. This information will not be included in the Operational Trajectory.

TABLE IV.- LOI ΔV VARIATIONS

ΔV , variations, fps			
Launch date			
July 5, 1970	July 10, 1970 ^a	August 3, 1970	August 9, 1970
^b 2956 ↓ ^c 2963	^b 2780 ↓ ^c 2967	^b 2825 ↓ ^c 2816	^b 2964 ↓ ^c 2909

^aThis information is supplied for general information only because it is not planned to go to the backup site in July. This information will not be included in the Operational Trajectory.

^b72° launch azimuth.

^c96° launch azimuth.

TABLE V.- CSM LUNAR PARKING ORBIT SUMMARY

FOR LANDING, ASCENT, AND RENDEZVOUS

(a) July

Launch date	July 5, 1970		July 10, 1970 ^a
Lunar landing site	Littrow		6R
Sun elevation at landing, deg	72°-first	12.1	7.8
	96°-second	14.2	13.8
Approach azimuth at landing, deg	≈-90		≈-85
Selenographic inclination at landing, deg	21.7		5.7
Lunar orbit plane change no 1 (LOPC-1) ΔV, fps	85		128
Approach azimuth at ascent, deg	-87.65		-85.59
Inclination at ascent, deg	22.6		4.8

^aThis information is supplied for general information only because it is not planned to go to the backup site in July. This information will not be included in the Operational Trajectory.

TABLE V.- CSM LUNAR PARKING ORBIT SUMMARY
 FOR LANDING, ASCENT, AND RENDEZVOUS - Concluded

(b) August

Launch date	August 3, 1970		August 9, 1970
Lunar landing site	Littrow		6R
Sun elevation	72°-first	10.2	9.8
at landing, deg	96°-second	12.2	11.3
Approach azimuth			
at landing, deg		-90.0	-80.0
Selenographic			
inclination at		21.7	10.4
landing, deg			
LOPC-1 ΔV , fps		85	266
Approach azimuth			
at ascent, deg		-87.7	-80.9
Inclination at			
ascent, deg		22.6	2.2

TABLE VI.- CSM LUNAR PARKING ORBIT SUMMARY FOR
BOOTSTRAP PHOTOGRAPHY AND LANDMARK TRACKING PHASE

(a) July

Parameter	Launch date	
	July 5, 1970	July 10, 1970
Bootstrap site	Hadley	To be determined (TBD)
Approximate sun elevation for site photography and tracking, deg	13	TBD
LOPC-2 ΔV , fps (to set up photography and tracking)	207	TBD
Post-LOPC-2 inclination, deg	24.8	TBD
Post-LOPC-2 longitude of ascending node, deg	90.5	TBD
g.e.t. of closest approach to photographic site, hr	First injection opportunity	158:19
	Second injection opportunity	160:48
		TBD

TABLE VI.- CSM LUNAR PARKING ORBIT SUMMARY FOR BOOTSTRAP

PHOTOGRAPHY AND LANDMARK TRACKING PHASE - Concluded

(b) August

Parameter	Launch date	
	August 3, 1970	August 9, 1970
Bootstrap site	Hadley	To be determined (TBD)
Sun elevation angle, deg	11	TBD
LOPC-2 ΔV , fps	207	TBD
Post-LOPC-2 inclination, deg	24.8	TBD
Post-LOPC-2 longitude of ascending node, deg	90.5	TBD
g.e.t. of closest approach, hr:min	First injection opportunity	TBD
	Second injection opportunity	
	158:19	
	160:48	

TABLE VII.- TEI AND TRANSEARTH COAST VARIATIONS

(a) July

Parameter	Launch azimuth, deg, and opportunity	Launch date	
		July 5, 1970	July 10, 1970 ^a
TEI ΔV, fps	72 - 1 96 - 2	2876 2985	2890 2967
Transearth flight time, hr	72 - 1 96 - 2	76.3 71.9	70.0 66.6
Entry speed, fps	72 - 1 96 - 2	36 044.7 36 047.6	36 017.4 36 019
Local earth landing time, hr:min	72 - 1 96 - 2	6:31 6:38	11:33 11:43
Local sunrise time at landing, hr:min		5:34	5:24
Total mission time, days:hr	72 - 1 96 - 2	10:04 10:01	10:08 10:05

^aThis information is supplied for general information only because it is not planned to go to the backup site in July. This information will not be included in the Operational Trajectory.

(b) August

Parameter	Launch azimuth, deg, and opportunity	Launch date	
		August 3, 1970	August 9, 1970
TEI ΔV, fps	72 - 1 96 - 2	3093 3241	2760 2796
Transearth flight time, hr	72 - 1 96 - 2	68.4 64.4	79.5 76.5
Entry speed, fps	72 - 1 96 - 2	36 045 36 050	36 010 36 010
Landing time, hr:min	72 - 1 96 - 2	6:17 6:24	11:50 11:58
Local sunrise time at landing, hr:min		5:36	5:50
Total mission time, day:hr	72 - 1 96 - 2	10:05 10:02	10:09 10:07

TABLE VIII - END OF MISSION SUMMARY

(a) July

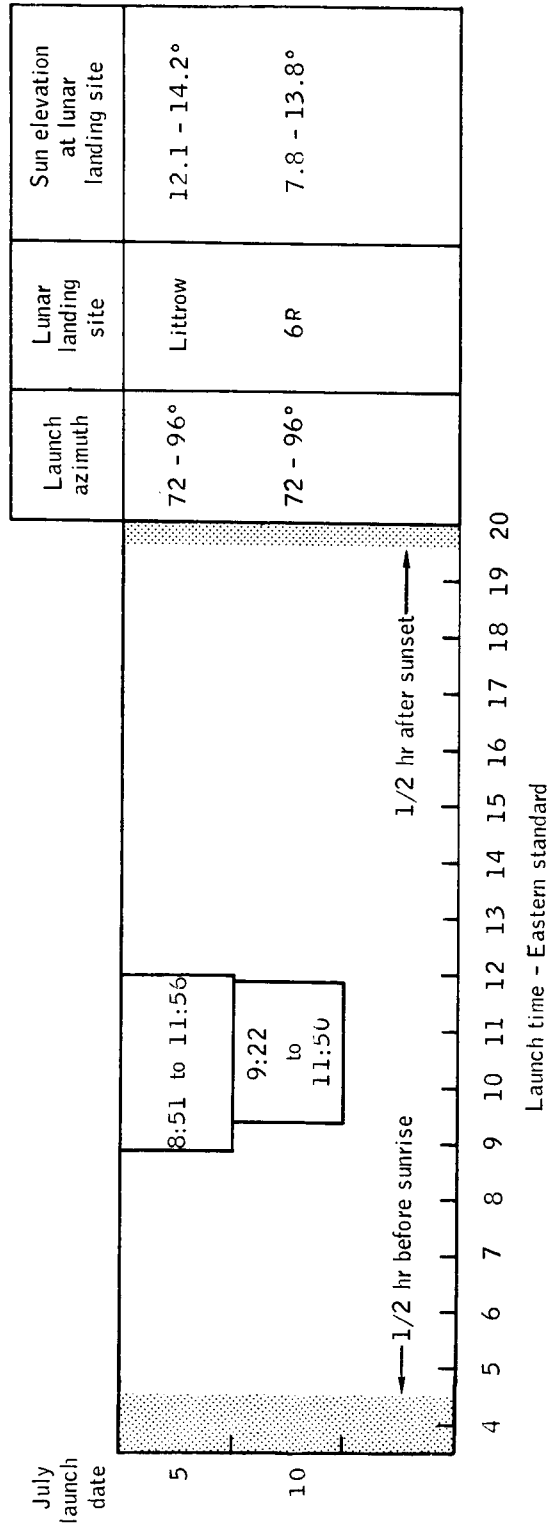
Parameter	Launch azimuth, deg, and opportunity	Launch date	
		July 5, 1970	July 10, 1970 ^a
Total mission time, day:hr	72 - 1	10:04	10:08
	96 - 2	10:01	10:05
End of mission ΔV reserve, fps (3 σ low with bootstrap photography and short transearth flight time)	72 - 1	1384	1842
	96 - 2	1267	1773
Contingency end of mission ΔV reserve, fps (3 σ low with worst case LM rescue, no bootstrap photography and long transearth flight time)	72 - 1	903	1069
	96 - 2	847	1092

^aThis information is supplied for general information only because it is not planned to go to the backup site in July. This information will not be included in the Operational Trajectory.

TABLE VIII - END OF MISSION SUMMARY - Concluded

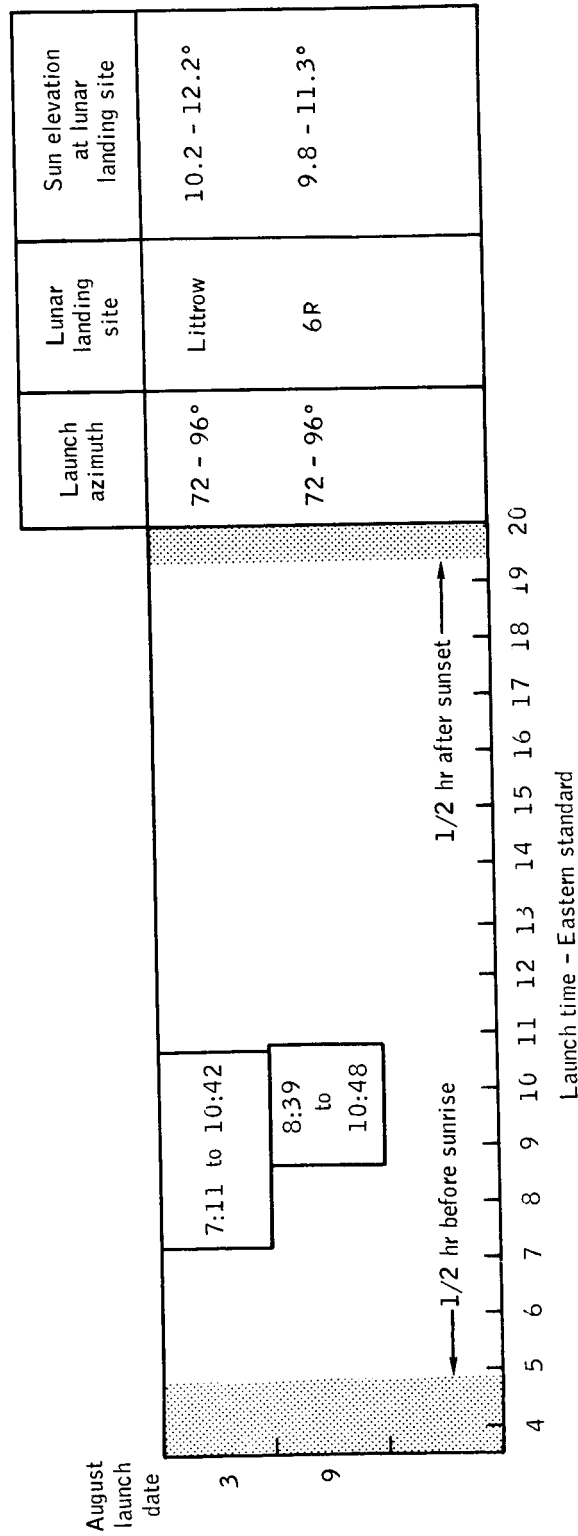
(b) August

Parameter	Launch azimuth, deg, and opportunity	Launch date	
		August 3, 1970	August 9, 1970
Total mission time, day:hr	72 - 1	10:05	10:09
	96 - 2	10:02	10:07
End of mission ΔV reserve, fps (3 σ low with bootstrap photography and short transearth flight time)	72 - 1	1410	1280
	96 - 2	1273	1353
Contingency end of mission ΔV reserve, fps (3 σ low with worst case LM rescue, no bootstrap photography and long transearth flight time)	72 - 1	1083	603
	96 - 2	1065	707



(a) July launch.

Figure 1.- Apollo 14 daily launch window summary.



(b) August launch.

Figure 1. - Concluded.

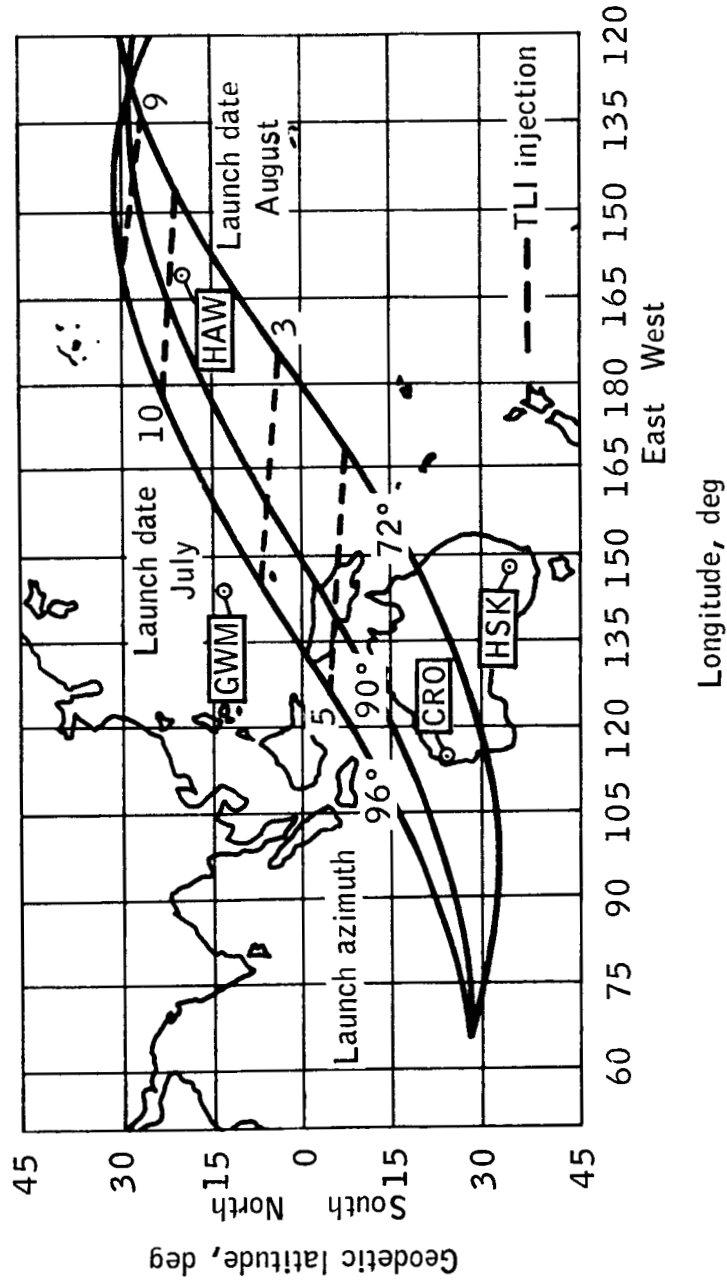
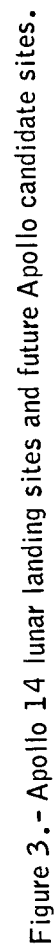


Figure 2.- Translunar injection positions, first opportunity only.



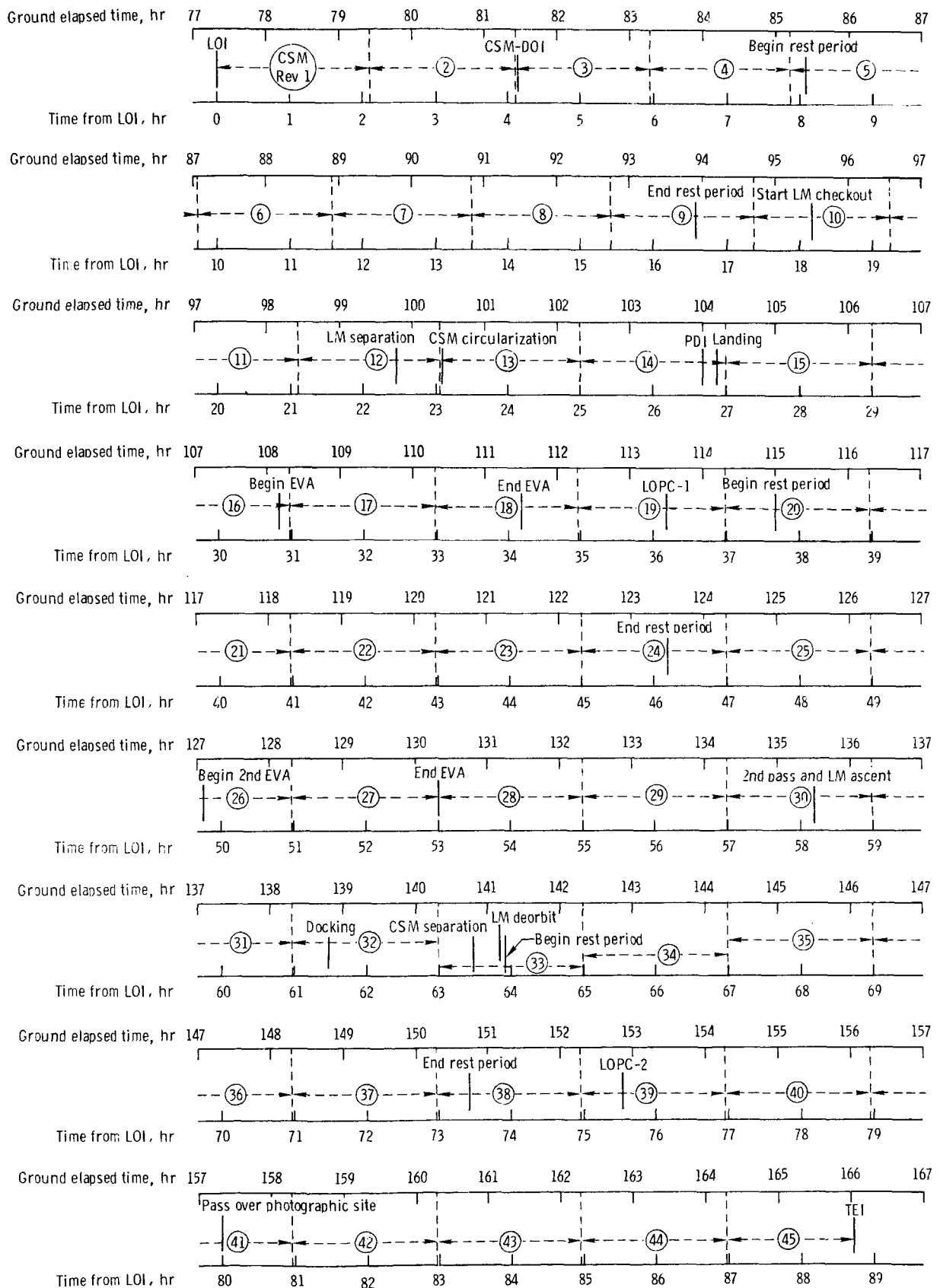
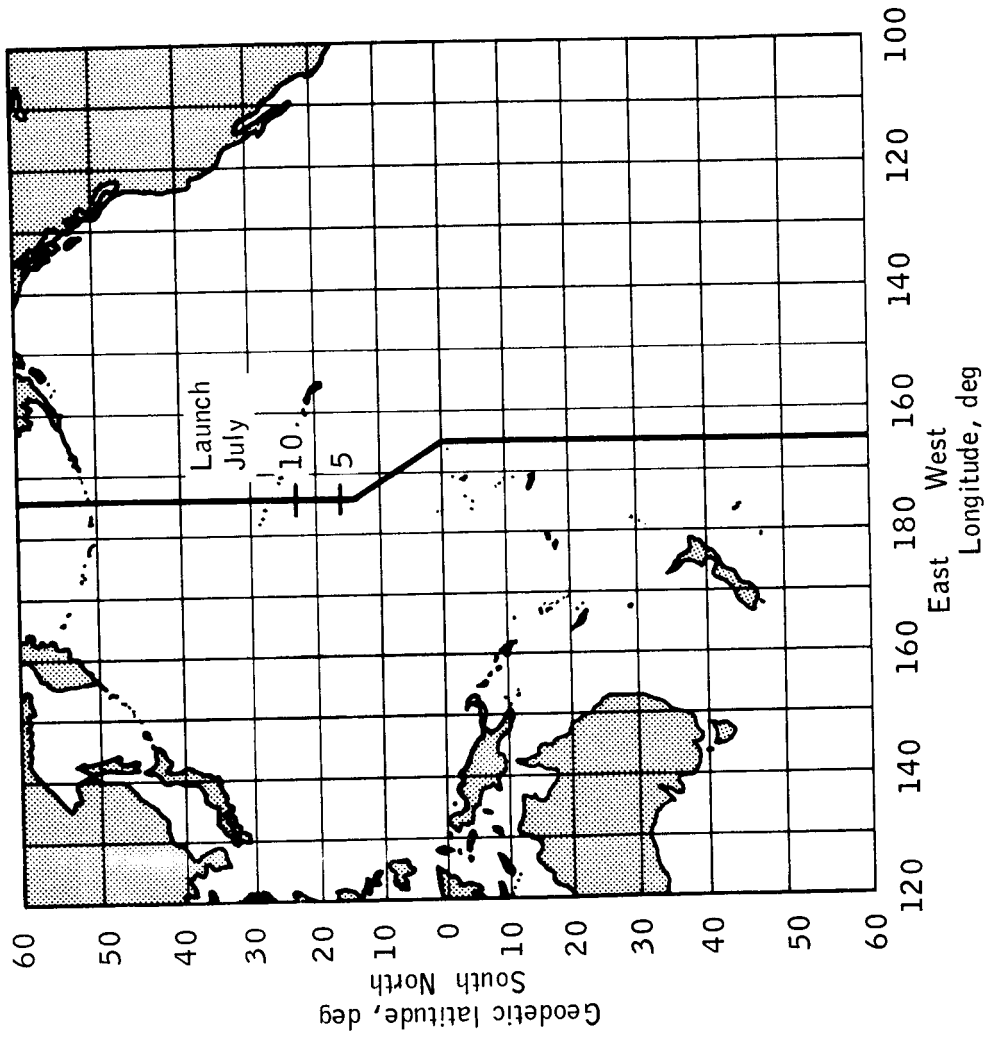
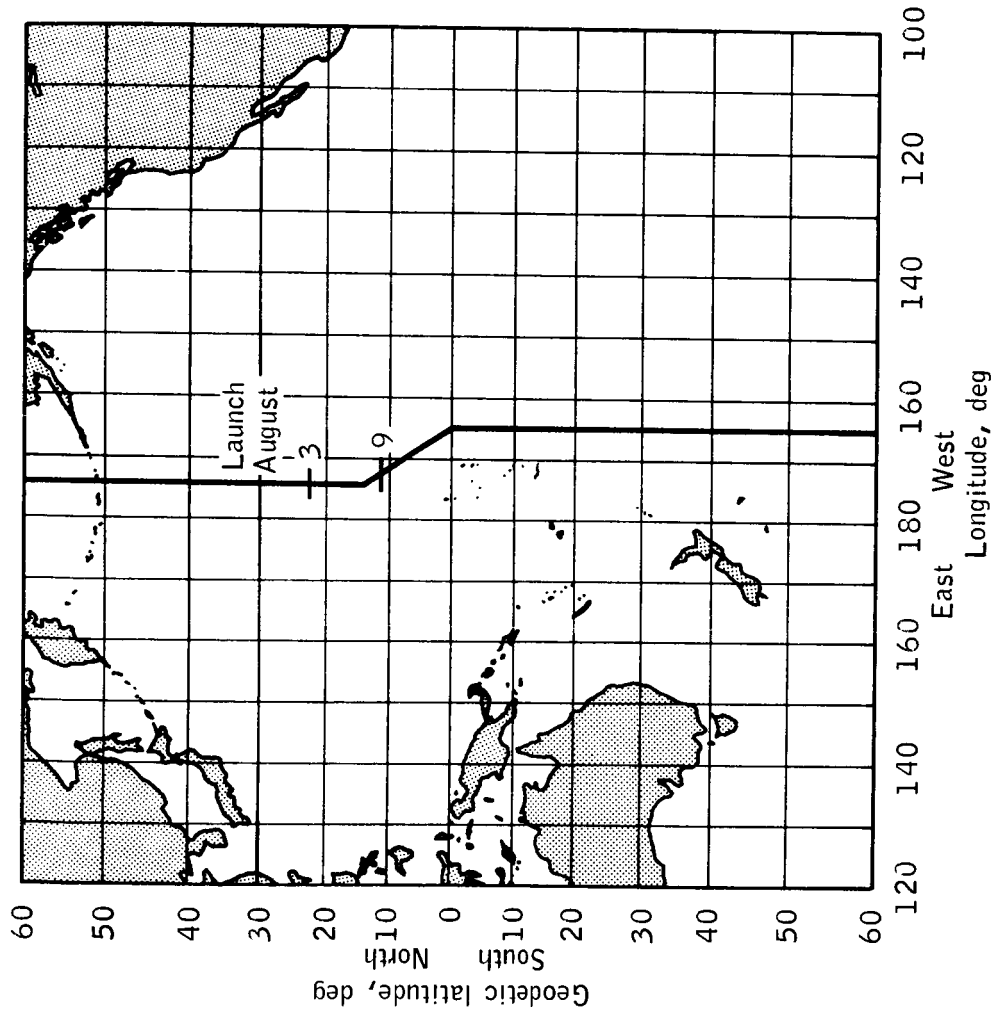


Figure 4. - Lunar parking orbit time line.



(a) July launch.

Figure 5.- Apollo 14 landing loci.



(b) August launch.

Figure 5. - Concluded.